

EXTENSION OF THE NAVY LAYERED OCEAN MODEL TO SHALLOW SEAS: A HYBRID COORDINATE APPROACH

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LONG-TERM GOALS

The goal of this work is to extend the geographic range of applicability of isopycnal coordinate models, such as the Navy Layered Ocean Model, toward shallow coastal seas. The numerical innovation making this extension possible is the “hybrid” (mixed isopycnal/terrain following) vertical coordinate.

OBJECTIVES

- (a) Demonstrate the feasibility of the hybrid coordinate approach in a basin encompassing both deep and shallow regions. Selection of the basin is to be guided by the richness of circulation-related phenomena and by the availability of observations allowing assessment of model performance.
- (b) Port the algorithm developed in phase 1 to the NLOM.

APPROACH

A hybrid coordinate, in this particular context, is one that is isopycnal in the open ocean but smoothly reverts to a sigma (terrain-following) coordinate in shallow coastal seas. The theoretical background for implementing such a coordinate was laid in papers published by the PI in 1981 and 1993 (Bleck and Boudra, 1981; Bleck and Benjamin, 1993).

In a hybrid model, each grid point is assigned a reference isopycnal. The model continually checks whether grid points lie on their reference isopycnals and, if not, tries to move them vertically toward the latter. However, grid points are not allowed to migrate if this would lead to excessive crowding of coordinate surfaces. Thus, in shallow water, grid points are geometrically constrained and stay in place while in deep water they are allowed to move up and down with their reference isopycnals. Model equations must be formulated in a way that makes no assumption about whether a particular grid point lies on its reference isopycnal or not. Care must be exercised in maintaining a smooth horizontal transition between the isopycnal and the sigma domain.

WORK COMPLETED

Early in this project, agreement was reached with the NLOM group to make the Gulf of Mexico the test bed for a prototype hybrid model and to do the initial development work with the Miami

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Isopycnic Coordinate Ocean Model. A reliable open-boundary version of MICOM (in the traditional non hybrid configuration) did not exist at that time, and development of such a model was considerably more difficult than anticipated. Only in early summer 1997 was the PI able to complete this phase of his work.

RESULTS

Results from hybrid model runs are not available yet, but an open-boundary, fine-mesh version of MICOM has been created that will serve as test bed for the hybridization attempt. This model is designed to be driven by time-dependent lateral property fluxes furnished by a coarse-mesh, global- or basin-scale version of MICOM. The open-boundary version has been successfully tested by the PI and two RSMAS students in several regions of the world ocean (Gulf of Mexico, Somali Current, Brazil Current). A detailed diagnostic study presently being conducted by a third RSMAS student indicates that Loop Current eddy shedding in the Gulf of Mexico model, thanks do the regional model's high resolution (0.07°), bears uncommonly strong resemblance to reality.

Hybridization work is underway. The raw numerical aspects are under control, thanks to the existence of a hybrid atmospheric prototype (Bleck and Benjamin, 1993; Benjamin et al., 1994). Current focus is on the “physics” routines in MICOM, such as the Kraus-Turner mixed layer scheme, and on the extent to which they have to be modified to serve satisfactorily in both the isopycnic and the sigma coordinate domain.

IMPACT/APPLICATIONS

Initiation of the MICOM/NLOM hybridization project was announced at the February 1997 MICOM users' workshop. Judging from the number of inquiries the PI has received since then, a hybrid model is eagerly anticipated by the community, given the emphasis placed in recent years on modeling of coastal phenomena, and in particular on the control exerted on these by offshore circulation phenomena.

Of particular interest to the Navy will be a streamlining of the presently cumbersome procedure of driving near-shore models with output from a basin-scale isopycnic model. Differences in coordinate architecture (near-shore models invariably use fixed grids while NLOM-like models allow coordinate surfaces to migrate freely in the vertical) render this coupling difficult at present. The hybrid model will solve a major part of this problem by “delivering” at its near-shore boundary the required data at fixed depth intervals.

TRANSITIONS

The open-boundary MICOM version has been made available to the community. The PI is aware of at least five projects so far involving this model or its output.

RELATED PROJECTS

The hybridization work is firmly embedded in the MICOM development effort carried out at RSMAS. The freedom to adjust the vertical spacing of coordinate surfaces is expected to simplify the numerical implementation of some physical processes (mixed layer detrainment, convective adjustment, sea ice modeling, ...) without robbing the model of its basic layer architecture.

REFERENCES

Benjamin, S.G., K.J. Brundage, and L.L. Morone, 1994: Implementation of the Rapid Update Cycle. Part I: analysis/model description. *NOAA/NWS Technical Procedures Bull.* (Draft), Washington, D.C.

Bleck, R., and S.G. Benjamin, 1993: Regional weather prediction with a model combining terrain-following and isentropic coordinates. Part 1: model description. *Mon. Wea. Rev.*, 121, 1770-1785.

Bleck, R., and D. B. Boudra, 1981: Initial testing of a numerical ocean circulation model using a hybrid (quasi-isopycnic) vertical coordinate. *J. Phys. Oceanogr.*, 11, 755-770.